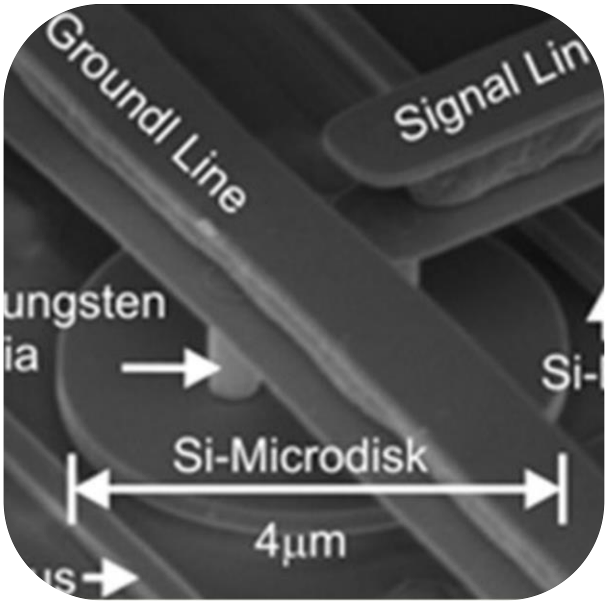
Silicon Photonics for Low- Energy Optical Communications

To support the needs of next generation of optical communications, researchers have developed a Sandia Silicon Photonics platform that leverages the semiconductor and nanotechnology capabilities of Sandia's MESA (Microsystems and Engineering Sciences Applications) complex to reduce the power dissipation of interconnects within digital systems.



Improving Interconnection Performance

As integrated circuit chips now incorporate over a billion transistors, and single boards provide multi-teraflop (1012) computing capacity, the bandwidth and energy required to communicate data within and between integrated circuits is becoming a primary performance bottleneck. Information and communications technology (ICT) is responsible for up to 10% of the US electricity consumption, with data centers responsible for about one fourth that total.

Unlike lighting, heating, and cooling, where power consumption is decreasing in the coming decades, ICT power consumption is projected to increase dramatically. Silicon photonics offers a potential breakthrough in data interconnection performance, not just for supercomputer applications, but also for data centers, local area networks, and even long distance communications. Importantly, silicon photonics can ride on the progress of silicon electronics and, when mature, will likely achieve the high yield, high reliability, and low costs common in the electronics industry.

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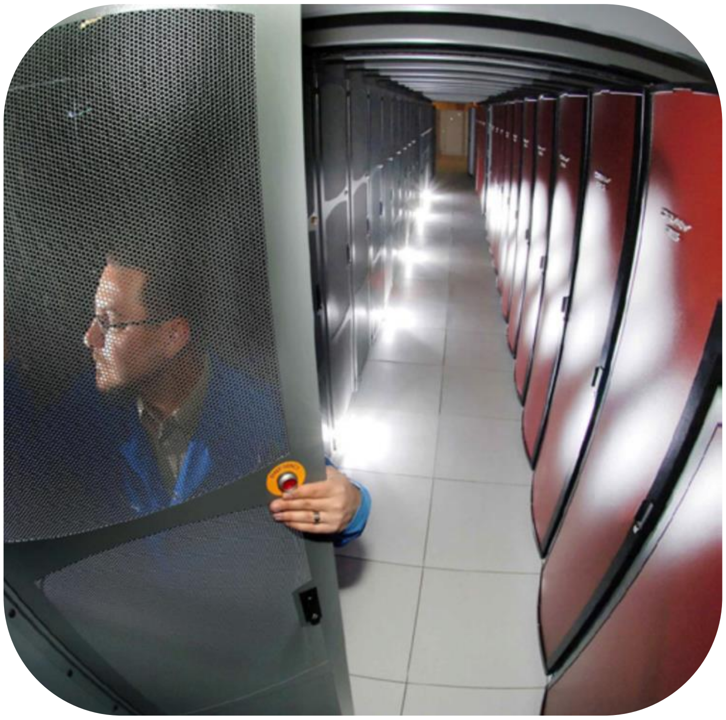
For additional information, visit our website at: **www.sandia.gov/mstc**

MICROSYSTEMS SCIENCE, TECHNOLOGY & COMPONENTS

Enabling Power Savings



Silicon photonics devices are comprised of silicon nanowire waveguides clad in silicon dioxide (SiO_2). The large refractive index contrast between the silicon waveguide and the oxide cladding allows light to be routed in the waveguide. Because the micro-disk resonators are so small, resonant electrically controlled optical modulators can have capacitances as low as 20 femtofarads, and can operate with an electrical power usage of as little as 3.2 femtojoules (fJ) per bit or 40 µW for 12.5 gigabits per second of information. This is about three orders of magnitude less power than it takes to electrically communicate information at the same data rate. This power savings is critical in high performance computing and satellite communications, especially for communications from cooled focal plane arrays. Preliminary cryogenic and radiation testing results suggest a promising future for Si Photonics devices to operate in space.

Sandia has demonstrated many leading-edge silicon photonics devices for applications in communications, sensing, and computing. In addition to the optical resonant modulator described above, we have demonstrated silicon photonics optical switching building blocks for optical networks that may enable lower energy consumption in some applications by avoiding the optical to electrical to optical conversions that are part of optically interconnected electrically routed networks.

Commercialization Path

Sandia has a complete silicon photonics platform and the expertise to design silicon photonics devices for a variety of applications. We are actively seeking partners and collaborations on projects related to low energy optical communications and computing, as well as other areas of importance to energy security and national security as a whole. We also welcome discussions and partnerships with commercial entities interested in product prototyping and low-volume product manufacturing (in multi-user projects or custom lots), and fabrication technology transfer to commercial foundries. Sandia's Silicon photonics intellectual property portfolio, encompassing over 15 issued and pending patents and patents under preparation, is available for licensing.

U.S. DEPARTMENT OF ENERGY
National Nuclear Security Administration

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